

The ultimate test of man's conscience may be his willingness to sacrifice something today for future generations whose words of thanks will not be heard.

Gaylord Nelson (1916–2005), Wisconsin senator and founder of Earth Day

INTERNATIONAL ENVIRONMENTAL HEALTH

Assessing the Global Composite Impact of Chemicals on Health

The total role that the environment plays in contributing to premature death and disability remains sketchy, but researchers working with the World Health Organization (WHO) continue to flesh out the details. Now four WHO researchers have estimated the global burden of certain toxic substances for which adequate data are available.¹ They have calculated that in 2004² at least 8.3% of all preventable deaths and 5.7% of the preventable portion of the metric known as disability-adjusted life years (DALYs, which address a blend of death and disease impacts) were caused by the toxics analyzed.¹ Their estimates include health end points such as cardiovascular disease, cancers, neuropsychiatric disorders, asthma, chronic

obstructive pulmonary disease, respiratory infections, and birth defects.³

The leading contributors to premature death and DALYs were indoor solid fuel combustion (1,965,000 deaths and 41,009,000 DALYs), outdoor air pollution (1,212,000 deaths and 8,747,000 DALYs), secondhand tobacco smoke (SHS; 603,000 deaths and 10,913,000 DALYs), chronic occupational exposures (581,000 deaths and 6,763,000 DALYs), chemicals involved in unintentional, nonoccupational acute poisonings (210,000 deaths and 4,603,000 DALYs), and suicide attempts using pesticides (186,000 deaths and 4,420,000 DALYs). Other toxics included in the global totals were asbestos, lead, arsenic in drinking water (but only in Bangladesh), and a few other chemicals, including some typically encountered in occupational settings.¹

Children under age 15 years were a highly susceptible group, suffering 54% of the total DALY burden. That includes 80% of the burden imposed by lead, 75% of that of indoor solid fuel use, 61% of that of SHS, 19% of

that of acute accidental poisonings, and 10% of that of outdoor air pollution.¹

The estimates include only a small fraction of all plausible chemical actors, says lead author Annette Prüss-Ustün. Among the thousands of toxics and pathways not included were mercury, dioxins, cadmium, radioactive substances, chronic pesticide exposures, active tobacco smoking, nonurban outdoor air pollutants, site-specific pollution hot spots, and chemicals whose actions are altered by climate change.

Nevertheless, Prüss-Ustün and colleagues think their analysis covers a high percentage of all acute impacts and a moderately high portion of all elevated chronic occupational exposures, although only a modest fraction of all chronic exposures in the general population, and almost none of the impacts such as developmental damage, degradation of specific organs or body systems, or harm caused by the extensive synthetic chemical body burden documented to occur in many people.¹



Leading contributors to premature death and DALYs¹

Indoor solid fuel use	2.0 mil deaths 41.0 mil DALYs (75% of burden falls on children under age 15 years)
Outdoor air pollution	1.2 mil deaths 8.7 mil DALYs (10% of DALY burden falls on children under age 15 years)
Secondhand Smoke	0.6 mil deaths 10.9 mil DALYs (61% of DALY burden falls on children under age 15 years)
Chronic occupational exposures	0.6 mil deaths 6.8 mil DALYs
Accidental nonoccupational chemical exposures	0.2 mil deaths 4.6 mil DALYs (19% of DALY burden falls on children under age 15 years)
Suicide attempts with pesticides	0.2 mil deaths 4.4 mil DALYs

Kemal Jufri/Panos Pictures

The WHO team's findings were based on evidence provided in numerous existing studies, including meta-analyses when available. To estimate the burdens, the team usually used a comparative risk assessment method that attempts to identify harm caused by factors such as the concentration of a substance above safe levels, such as particulate matter (PM) emitted by vehicles or combustion of solid fuels. When there was substantial but limited data that precluded using this method alone, expert opinion was used to fine-tune the estimate.

These methods have been used for many years and seem to be well applied in this study, says Jonathan Samet, director of the Institute for Global Health at the University of Southern California. But he says the mitigation efforts needed to reduce these impacts continue to struggle. "We don't have a strategy in place to deal with the many chemicals coming along that our society appears to want and need," he says, pointing to engineered nanoparticles as one example.

Nsedu Obot Witherspoon, executive director of the U.S.-based Children's Environmental Health Network, says the new findings provide some additional insight on the global problem, but that even with the gaps and limitations in the study, there already is enough information to support taking more aggressive action on many toxics. "We're wasting good time," she says. "We need to jumpstart this quickly. People are dying."

For example, Witherspoon says she's surprised some parents still don't understand the connection between SHS exposure and related health problems in their children. "I know that most parents don't deliberately want to harm their children," she says. "So there is still a basic need for more public education messages on the impacts of secondhand smoke."

On other issues, she says that, absent federal regulation, other jurisdictions can use known remedies that are already proving successful, such as siting new schools and child-care facilities away from high-traffic roads, or eliminating or reducing bus idling near these facilities—strategies that may reduce schoolchildren's exposures to various toxics.⁴ Another viable strategy, she says, is providing clearer labeling on products so consumers can make better-informed decisions about the chemicals they are exposed to. She also encourages substantially expanding existing biomonitoring programs to cover more people and more toxic substances. Without this, she says, "we are missing a huge piece" of understanding who's exposed to what chemicals and what these exposures mean for human health.

Witherspoon also suggests that policy makers would benefit from reviewing the

underlying assumptions of laws passed long ago that may no longer be on target, such as cigarette ignitability standards for mattresses and mattress pads⁵ in an era when far fewer people are smoking in bed.⁶ And for future efforts conducted by organizations such as the WHO, one of her highest priorities is to track global data on the impacts of consumer product ingredients for which a growing body of evidence suggests adverse health effects, such as bisphenol A, phthalates, and polybrominated diphenyl ether flame retardants.

Expanding beyond the realm of chemical impacts, the WHO and more than 100 experts from around the globe have already evaluated a wide range of environmental factors thought to have a link with 85 significant diseases.³ Their definition of the environment is broad and includes all physical, chemical, and biological factors external to individuals, and all related behaviors, but excluding any natural factors that can't be alleviated in the short or long term with current methods.³ Among the specific factors addressed to some degree so far are water, sanitation, and hygiene problems, malnutrition, overcrowding, numerous microbial diseases, and various types of accidents and injuries.

They are concluding that 23% each of all preventable global deaths and DALYs are caused by one environmental factor or another, with large variations among countries in magnitude, sources, and allocation of impacts. The burden ranges from 13% in countries such as Canada, Cyprus, Israel, Singapore, Switzerland, and the United States, to more than one-third in harder-hit countries such as Niger (37%), Angola (36%), Sierra Leone (35%), Burkina Faso (34%), and Mali (33%).

As part of their work, the researchers have developed a fact sheet for each country, in which certain details are broken out. For the latest work on chemicals, only indoor solid fuel use and the burden imposed by outdoor air pollutants, using PM₁₀ as a surrogate, are listed. Prüss-Ustün says the sheets provide some initial context, but that country-specific detail on many factors has deliberately been left out. "[We would] rather have the countries estimate these themselves, as they may have more precise estimates of exposure than we do," she says.

As an example of the information provided on the sheets, the annual death toll in the United States from PM in outdoor air is estimated at 40,600 for the year 2004.⁷ This is a conservative number compared with the U.S. Environmental Protection Agency's (EPA) estimate of 63,000–88,000,⁸ but it is 69% higher than what was estimated in a study published in 2004 by researchers from the U.S. Centers for Disease Control and

Prevention (CDC).⁹ The CDC researchers added another 31,000 deaths from various toxics to determine a total toxics death toll of at least 55,000 in 2000.¹⁰ Adding the same 31,000 to the top end of the EPA estimate, which does not include deaths from hundreds of outdoor air pollutants, leads to a total of 119,000 deaths. Those assumptions would mean that toxics were the fifth leading killer in 2004, worse than all accidents (112,012 deaths, including 48,053 from transportation-related accidents), all microbial vectors except for influenza and pneumonia (65,275 deaths), influenza/pneumonia (59,664), drug overdoses and adverse reactions (30,711), firearms (29,569), and alcohol (21,081).¹¹

The numbers indicate toxics are a leading cause of death, but Samet says it's impossible to determine if these agents are being adequately addressed in the United States. "I have not seen anything like a collective analysis of whether the combination of all regulatory, research, education, and related efforts mesh with the actual death and disease burden for various environmental agents," he says.

He says the new WHO study could potentially spur greater interest in figuring this out in the United States and other countries, but he wonders if the WHO's studies and others like them, which have been conducted since the 1990s, are having any real impact. "Do these efforts turn out to be useful to policy makers?" he asks. "It'd be nice to get a better handle on how the world is using them."

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INDOOR AIR QUALITY

Wood-Burning Stoves Get Help from HEPA Filters

In many regions wood is seen as a cheap, renewable resource, and burning wood to heat homes is prevalent in rural and urban areas of North America and Europe.¹ A small, preliminary study suggests air purifiers equipped with high-efficiency particle air (HEPA) filters can lower the amount of indoor fine particulate matter (PM_{2.5}) and smoke from woodstoves, potentially reducing residents' risk of cardiovascular disease from exposure to these air pollutants.² "Our study is the first that I'm aware of that has shown any measurable health benefit from HEPA filtration in wood-burning communities in relatively young, healthy people," says study leader Ryan Allen, an assistant professor of health sciences at Simon Fraser University, Burnaby, British Columbia.

The researchers monitored 45 nonsmoking adults, average age 43 years, living in 25 homes in Smithers, British Columbia, where residential wood burning is common. Air purifiers costing about \$150 were placed in the most active room of the house and the bedroom. The air purifiers ran for 7 days with the HEPA filter inserted and another 7 days without. The order of filter and control conditions was randomly selected for each participant, and participants were unaware of filter status.²

Levels of PM_{2.5} and levoglucosan, a validated tracer of woodsmoke, were measured inside and outside the homes. At the end of each 7-day period, blood and urine samples were assessed for markers of inflammation and oxidative stress, and microvascular endothelial function was measured by peripheral artery tonometry.²

Use of the HEPA filters reduced indoor PM_{2.5} concentrations by 60%, and indoor levoglucosan levels fell by 75% on average, compared with nonuse. HEPA filtration was linked to a 9.4% increase

in the reactive hyperemia index (RHI), a marker of endothelial function, and a 32.6% decrease in C-reactive protein, a marker of inflammation.² A reduced RHI reflects an impaired blood vessel response to changes in blood flow and is an early indicator of atherosclerosis.³ These physical changes occurred even though PM_{2.5} levels were relatively low to begin with—about 11 µg/m³ outdoors compared to the U.S. Environmental Protection Agency's annual average standard of 15 µg/m³.⁴

Even people who don't use woodstoves themselves may benefit from HEPA filters, Allen says. "Most stoves don't put smoke into your living room directly," he explains; instead, smoke that is vented outdoors leaks back into nearby homes through cracks around doors and windows.²

A larger, better-controlled study is needed to confirm these findings, as well as determine any long-term health benefits of filtering indoor air, such as preventing strokes or heart attacks. Still, these initial results are promising in a world where indoor air pollution from solid fuels such as wood is a top global risk factor for disease and premature death.⁵ Moreover, says Lars Barregard, a professor of occupational and environmental medicine at the University of Gothenburg, Sweden, "The use of wood for heating may become more common as the cost of other fuels rise or fossil fuels are restricted."

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The Beat

by Erin E. Dooley

DOI to Study Chukchi Oil Spill Impact

As part of a court-ordered supplemental review of oil and gas leasing off Alaska's northwest coast, the Department of the Interior will assess potential environmental impacts of a major oil spill in the Chukchi Sea.¹ The court order resulted from a summer 2010 ruling that found the department had not properly analyzed

the environmental impacts of natural gas development related to a 2008 lease sale of 2.8 million acres in the area. A revised draft of the environmental impact statement should be ready by summer 2011 and will be open for 45 days for public comment, with the final review expected by October.

PBDEs Off Wal-Mart Shelves

Beginning in June 2011 Wal-Mart will implement testing measures to verify compliance with its ban on polybrominated diphenyl ether (PBDE) flame retardants in certain products on its shelves.² Wal-Mart's efforts come without any federal regulation on the compounds, which only recently have begun to be regulated at the state level. Sampling during the National Health and Nutrition Examination Survey 2003–2004 revealed PBDEs in the bodies of nearly every participant tested.³ Although health effects data are still limited for these compounds, their persistence and ubiquity have raised substantial scientific concern.



EPA Proposes Third Unregulated Contaminant Monitoring Reg

The U.S. EPA recently proposed monitoring for 30 currently unregulated drinking water contaminants, including 28 chemicals and 2 viruses.⁴ The monitoring data would provide information about the prevalence of contaminants on the list to support future EPA decision making. Among the chemical

Left to right: Joseph Tarr/EHP and Frank Ramsdell/Stockphoto; Alexus/Shutterstock

INNOVATIVE TECHNOLOGIES

MRI-Based Atlas of the Developing Mouse Brain Debuts

The mouse is one of the major animal models for toxicologic research, but histologic analyses are notoriously slow, taking a week or longer. A new magnetic resonance imaging (MRI)-based atlas of the developing mouse brain now provides a badly needed baseline for studies of how pollutants and genetic mutations affect brain development in mouse models.¹ The atlas traces the development and growth not only of the entire mouse brain and its constituent parts but also of its white matter and connectivity,² day by day, from embryonic day 12 to postnatal day 80.

The new brain atlas greatly reduces the amount of work necessary to determine the effect of either mutations or pollutants on brain development, says coauthor Susumu Mori, a professor in the Department of Radiology at the Johns Hopkins University School of Medicine. Typically, one would harvest tissue samples at different points in development and perform histologic analyses, he says, but the lack of prior knowledge of which structure is altered by a given exposure necessitates creating hundreds of histology sections—an arduous task. “Our idea,” he says, “is to do three-dimensional microimaging [with MRI], which can capture the anatomy of the entire brain within a day.” For that, the mouse brain atlas provides the baseline.

This baseline is ideal for determining changes in growth rates that might arise from neurotoxicities, says G. Allan Johnson, director of the Duke University Center for *in Vivo* Microscopy, who was not involved in the research. “My personal opinion,” he says, “is that MR imaging—MR histology in particular—will become one of the major ways to produce quantitative measures of environmental toxicology.”

The atlas quantifies the whole brain of the widely used C57BL/6 mouse, as well as the neocortex, cerebellum, hippocampus, and more than 17 other substructures, with additional substructures being added steadily. It also maps the white matter tracts and the gray matter structures. Additionally, it characterizes anatomical variability at several developmental stages.¹ Complementary use of the high-resolution technique known as diffusion tensor imaging helped boost the normally poor tissue contrast provided in immature mouse brain samples by MRI alone.

“The ability to have a three-dimensional map of the developing brain is very important for studying neurotoxicology and developmental neuroscience,” says Tomás Guilarte, the Leon Hess professor of Environmental Health Sciences at Columbia University’s Mailman School of Public Health, who has worked in the past with Mori. In terms of future utility, Guilarte sees the mouse brain atlas as having a breadth of applications comparable to polymerase chain reaction.

The new atlas supercedes histology-based atlases that have very limited coverage of different developmental stages, says Mark Henkelman, director of the Mouse Imaging Center at the Hospital for Sick Children in Toronto, who was not involved in the research. Henkelman says the developmental breadth of the atlas could offer critical clues to predict whether a toxicant poses a special threat to pregnant mothers or children need to avoid, or whether it’s likely to affect the entire population.³

David C. Holzman writes on science, medicine, energy, economics, and cars from Lexington and Wellfleet, MA. His work has appeared in *Smithsonian*, *The Atlantic Monthly*, and the *Journal of the National Cancer Institute*.

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contaminants are several perfluorinated compounds, endogenous and exogenous hormones, and metals; 1,3-butadiene, a human carcinogen; and 1,2,3-trichloropropane, an animal carcinogen. The public may comment on the proposed list through 2 May 2011.

Higher Latitudes See Longer Ragweed Season

One significant cause of seasonal allergies is plants from the genus *Ambrosia*, which includes several types of ragweed. A study of ragweed pollen data from 10 U.S. and Canadian sites shows the duration of the pollen season increased by up to 27 days since 1995 at latitudes above about 41°N.⁵ Papillion, Nebraska, at 41.15°N, has a season 11 days longer than in 1995, Minneapolis, Minnesota (45.00°N), has a season 16 days longer, and Saskatoon, Saskatchewan (52.07°N), has a season 27 days longer. An estimated 10% or more of the U.S. population is sensitive to ragweed pollen, and by one estimate allergies cost the United States approximately \$21 billion per year.⁵

Protests against New Asbestos Plant in India

Construction on an asbestos manufacturing plant in the Indian state of Bihar has come to a halt after six months of student-led protests, according to news reports from the subcontinent.⁶ Several dozen countries now ban most or all forms of asbestos,⁷ and earlier

this year, the Collegium Ramazzini reintroduced its call for a global ban on asbestos.⁸ An estimated 125 million people are exposed to asbestos in the workplace, and thousands of deaths and new diagnoses of asbestos-related disease are reported each year.⁸

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